able. Of the two errors greater than 0·05s., one is +0·072s. and the other −0·060s., and the magnitudes of the two stars are the same, and practically in the middle of the series.

But if there is no indication of a "magnitude equation" there is another circumstance which is not a little suspicious, and interesting as suggestive of the introduction of fresh sources of error. The author has referred to the fact that the mean error of observation can become comparatively large when the photographic image is poor, owing to the small altitude of the star. When the residuals are collected according to the zenith distance of the star, there is some indication of a connection between the two. "There is," says Prof. Hirayama, "a common tendency for the residual error to be least at the zenith, and to increase with the zenith distance." No stars below the pole have been observed, so that there is no means of comparing the results given by stars at small altitudes on opposite sides of the zenith. But many important questions are raised in this paper, and we notice with pleasure that Prof. Hirayama proposes to continue the inquiry. We can assure him that his investigations will be watched with interest in this country.

THE MUSEUMS ASSOCIATION.

THE seventeenth annual meeting of the Museums Association was held in Bristol on July 2–5 under the presidency of Dr. W. E. Hoyle, director of the Manchester Museum. The attendance of curators and representatives from various British museums was greater than in any previous year, foreign museums and museum workers being also represented by Geheimrat Dr. A. B. Meyer, of Dresden, Prof. Conwentz, of the Provincial Museum, Dantzig, Prof. Lehmann, of the City Museum, Altona, Mr. H. L. Brakstad, Norwegian Vice-Consul, and others.

The public conference commenced on the morning of July 3 in the Council House, a warm welcome being given to the association on behalf of the city by the Lord Mayor, High Sheriff, and museum committee, after which Dr. Hoyle gave the presidential address, taking as his subject the education of a museum curator. Briefly reviewing the varied training, or lack of training, which many curators have received, Dr. Hoyle divided museums into two great classes:—(*a*) museums of art, or institutions in which objects are regarded simply as material for æsthetic contemplation, where they are arranged so that each may be seen to the best advantage and minister to the cultivated enjoyment of the onlooker; and (*b*) museums of science, in which the object is to exhibit the state of human knowledge on one or more subjects, and to supply means of increasing that knowledge.

Confining his observations to the character of training required for curators of science museums, the president urged the necessity of a fair preliminary training in manual industry and the knowledge and use of tools, and afterwards a technical and scientific training in those subjects underlying the future work of the embryo curator. As subjects necessary to be studied because of their close relation to museum collections were enumerated the natural sciences, mineralogy, geology, biology, including in the latter term botany, zoology, anthropology, and ethnology. As sciences more nearly concerned with the acquisition, registration, preservation and exposition of museum collections were instanced the rudiments of mechanical engineering, physics, and chemistry. As a kind of post-graduate course, the necessity of visiting and studying the nature and methods of work of various museums was strongly insisted upon.

Alderman W. R. Barker, chairman of the Museum and Art Gallery committee, laid before the association a paper he had prepared tracing the rise and progress of the Bristol Museum from its inception in 1808 to the present union of museum and City Art Gallery.

Mr. H. Bolton, curator of the Bristol Museum, followed with a paper describing the general character of the collections, and the steps which had been taken to bring the mode of exhibition and usefulness of the museum contents up to modern requirements, mentioning that it was the intention of the committee to introduce a type-series of mounted specimens, an osteological series, and one in which the main structural features of the animal kingdom would be shown by prepared dissections. Work on similar lines was proceeding in other departments of the museum, and ultimately it was hoped to be able to place at the disposal of any student or visitor all that is necessary in the way of types for the full degree course of any university. Papers were also read by Mr. R. Quick, on the hanging of pictures; by Mr. F. R. Rowley, on a method of displaying coins, and on models of Protozoa; and by Mr. W. W. Watts, on the City plate and insignia.

Wednesday, July 4, was occupied with the discussion of a series of papers on museum cases and fittings, the subject being opened by Dr. A. B. Meyer, of Dresden, who outlined the result of his experiments and researches during the last thirty years upon museum cases. He strongly advocated metal and preferably iron cases, which could be made dust-proof, elegant in appearance, and not more costly than wooden cases. Dr. Meyer's remarks were followed by a paper from Mr. F. A. Lucas, of Brooklyn Museum, and one by Dr. Lehmann on a simple practical dust-proof case in the Altona Museum. Mr. Bantry White, of the Dublin Museum of Science and Art, exhibited an iron museum case built in that museum's own workshops, which was very efficient, dust-proof, and not costly.

A remarkable cabinet case, with changing trays each of which could be brought into view in turn by mechanical means, was exhibited and explained by the Rev. S. J. Ford. Mr. A. M. Rodger exhibited case fittings from the Perth Museum, and Mr. Woolnough, of Ipswich, complete models of cases it was proposed to introduce into the museum at that town. The lighting of museum cases was dealt with by Mr. Thos. White, of London. Dr. F. A. Bather explained the character of some cases in the British Museum, and illustrated his remarks, as did other speakers, by photographs and drawings. Mr. J. Osborne Smith also dealt with the same subject, and exhibited the original drawings and plans of many of the more recently made cases. Owing to the interest and importance of the subject the session was continued in the afternoon until four o'clock.

Thursday was occupied by a paper on the American Museum of Natural History, by Dr. H. C. Bumpus; by a paper on wall diagrams to illustrate prehistoric archæology, from Prof. Conwentz; a paper on the Altona room in the Arts and Crafts Exhibition, Dresden, designed to show how the form of animals is the concrete expression of adaptation to their suroundings; and one on the construction and management of museums of art, by Mr. B. Ives Gilman.

The afternoons and evenings of July 3 and 5 and the whole of Friday, July 6, were occupied by visits to the zoological gardens at Clifton, a conversazione at the Museum and Art Gallery, visits to the stone circles at Stanton Drew, the ancient British lake village near Glastonbury, the Glastonbury Museum, and the Cheddar Gorge and Caves. The meetings were well attended throughout, and a highly successful conference was brought to a close on Saturday last.

THE METEOROLOGY OF THE FREE ATMOSPHERE.

AT the request of the council of the Royal Society of Edinburgh, M. L. Teisserenc de Bort gave an address on the meteorology of the free atmosphere at the meeting of the society on May 21. Subjoined is a summary of his lecture.

The methods for sounding the atmosphere employed at the present day have been in our possession but a few years. The kite, carrying self-registering apparatus, was introduced by the Americans about fifteen years ago; the sounding balloon dates but twelve years back. The use of balloons, furnished with registering apparatus, was proposed by Lemonnier, a French physicist, at the end of the eighteenth century; but they were actually employed for the first time by the Brothers Renard, and especially by MM. Hermite and Besançon, whose first observations go back to 1893.

Observations of great interest had already been made on

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mountains. To these are now added observations made in air altogether free.

The distribution of the barometric pressure at a distance of several thousand metres above the ground was first examined, and maps were shown giving the isobars at 4000 metres as calculated from the pressure and temperature on the surface of the earth.

M. Teisserenc de Bort has carefully verified that the pressure in free air diminishes in accordance with the barometric formula. For that purpose he determined the heights of a large number of balloons by observing them with two theodolites. On the average the heights thus observed agree with those deduced from the barometers carried by the balloons to within 2 or 3 millimetres of barometric pressure for a height of 4000 metres. The maps of the isobars at 4000 metres show that most of the areas of high and of low pressure observed near the ground become effaced as we rise in the air, and give place to a pressure distribution of a much simpler kind, viz. a maximum of pressure all round the earth in the tropical regions, and low pressures at the poles. The average direction of cirrus clouds is in harmony with these conditions.

As regards the distribution of temperature, the following conclusions were established :—

(1) Even at a height of several thousand metres above the ground there is, contrary to what had been thought, a very sensible variation of temperature from winter to summer, the divergence of temperature between the coldest and the hottest month being 9° C. at 10 kilometres height.

(2) After it had been noticed that the rate of fall of temperature increases with the height above the ground, it was naturally supposed that temperatures at great heights in the air were extremely low. But sounding balloons despatched from the Trappes Observatory have proved that, after a certain height, varying from 9 to 14 kilometres, the fall of temperature ceases altogether—another fact that was wholly unexpected.

(3) The zone where the temperature ceases to fall, called the "isothermal zone," is situated nearer the ground (8 to 9 kilometres in certain places) with low pressures, and further from the ground (about 12 or 13 kilometres) above high-pressure areas.

(4) As a general rule, it is colder in the upper part of an anticyclone than it is at a corresponding height above low pressures, but the contrary holds at medium heights of about 5 kilometres. The absolutely lowest temperatures are observed near high pressures. A temperature of $-73°$ has been observed several times at Trappes, and recently as low as $-80°$ in Austria.

(5) Balloon flights made daily for a week or more at a time, in different years and at different seasons, have shown that at intervals of a few days the atmosphere experiences variations of temperature which are much more important high up than on the ground. At a height of 11 kilometres variations of 15° to 20° are often observed at a time when variations of only 2° to 3° are found near the ground.

It is believed that the arrest of the decrease of temperature is connected with the cessation at a certain height of movements of the air having a vertical component, the air then having movements which follow the isobaric surfaces. There is no longer any temperature variation due to expansion or compression of the air.

It has been demonstrated, alike by calculation of the isobars and by the flight of balloons, that most of the depressions which appear near the ground as complete atmospheric vortices suffer deformation as the height increases, and in their northern part lose themselves in the great polar vortex; so that, at a certain height (4 to 7 kilometres), east and north-east winds are no longer found to the north of a depression, and the isobars at this height form a handle attached to the low-pressure areas of northern latitudes. On the front of a depression its characters remain distinct to the top; a sheaf of ascending air reaches the height of cirrus cloud, and then spreads over the barometric maxima to east and south-east.

M. Teisserenc de Bort exhibited his very light, compact self-registering apparatus for measuring the temperature, pressure, and humidity in the upper regions of the atmosphere. Dr. W. N. Shaw, F.R.S., expressed the indebtedness of meteorologists to M. Teisserenc de Bort, whom he had come all the way from London to hear. After referring to the main points of the address, Dr. Shaw directed attention to another important line of research for which M. Teisserenc de Bort has fitted up a fish carrier, acquired at Hull, with the aid of which he is investigating at the equator the problem of the upper trade winds.

INTERNATIONAL SCIENCE.[1]

IN an address delivered to the British Association at its Belfast meeting in 1902 I expressed the opinion that meteorology might be advanced more rapidly if all routine observations were stopped for a period of five years, the energy of observers being concentrated on the discussion of the results already obtained. I am glad to say that meteorologists have taken this remark as being meant seriously, and its echoes still reach me from distant parts of the earth. They disagree with me, but their disagreement is of the apologetic kind. I do not wish to retract or to weaken my previous statement, but merely to qualify it now to the extent that it is only to be applied to two-dimensional meteorology. There is a three-dimensional meteorology as far removed from the one that confines itself to the surface of the earth as three-dimensional space is from a flat area. Three-dimensional meteorology is a new science, which at present requires the establishment of new facts before their discussion can properly begin. The extension of our range of observations by kites and balloons is of comparatively recent origin. Mr. Archibald in this country was one of the pioneers of meteorological investigation by means of instruments attached to kites. In the United States Mr. Rotch, having established a separate observatory, succeeded in convincing scientific men of the great value of the results which could be obtained. M. L. Teisserenc de Bort, who established and maintained an observatory for dynamic meteorology at Trappes, near Paris, rendered similar services with regard to "pilot" or unmanned balloons carrying autographical instruments. The aëronautical department of the Royal Prussian Meteorological Institute, with Dr. Assmann at its head, under the direction of Prof. von Bezold, also made a number of important contributions in the early stages of the work. Prof. Hergesell, of Strassburg, similarly made numerous experiments, and chiefly through the efforts of those whose names have been mentioned, and more especially Prof. Hergesell, an international agreement has been secured by means of which kite and balloon ascents are made in several countries on the first Thursday in each month, and on three consecutive days during two months of the year. A large station for aëronautical work was recently established at Lindenberg, near Berlin, where kites or balloons are sent up daily for the purpose of securing meteorological records. The greatest height yet reached was during the ascent of November 25, 1905, when by means of several kites sent one after another on the same wire, the upper one rose to an altitude of 6430 metres, almost exactly four miles. Owing to want of funds this country could until recently only participate in this work through the individual efforts of Mr. Dines, who received, however, some assistance from the British Association and the Royal Meteorological Society. The reconstruction of the Meteorological Office has made it possible now for Mr. Dines's work to be continued as part of the regular work of the office, and further stations are being established. Mr. Cave carries out regular ascents at his own expense at Ditcham Park, and through the cooperation of the Royal Meteorological Society and the University of Manchester, assisted by a contribution for apparatus from the Royal Society Government Grant Fund, a regular kite station is being established on the Derbyshire moors.

The International Committee which collates the observations is a commission appointed by a union voluntarily formed between the directors of meteorological observatories and institutes of countries in which regular observations are taken. The meeting of directors discusses schemes of observations and encourages uniformity.

If I mention a few of the difficulties which stand in the way of a homogeneous system extending over Europe, I

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[1] Discourse delivered at the Royal Institution on Friday, May 18, by Prof. Arthur Schuster, F.R.S. (Continued from p. 237.)

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